Evaluation of Mercury in Urine as an Indicator of Exposure to Low Levels of Mercury Vapor

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We conducted a pooled analysis to investigate the relationship between exposure to elemental mercury in air and resulting urinary mercury levels, specifically at lower air levels relevant for environmental exposures and public health goals (i.e., < 50 µg/m^3 down to 1.0 µg/m^3). Ten studies reporting paired air and urine mercury data (149 samples total) met criteria for data quality and sufficiency. The log-transformed data set showed a strong correlation between mercury in air and in urine (r = 0.774), although the relationship was best fit by a series of parallel lines with different intercepts for each study (R^2 = 0.807). Predicted ratios of air to urine mercury levels at 50 µg/m^3 air concentration ranged from 1:1 to 1:3, based on the regression line for the studies. Toward the lower end of the data set (i.e., 10 µg/m^3), predicted urinary mercury levels encompassed two distinct ranges: values on the order of 20 µg/L and 30–60 µg/L. Extrapolation to 1 µg/m^3 resulted in predicted urinary levels of 4–5 and 6–13 µg/L. Higher predicted levels were associated with use of static area air samplers by some studies rather than more accurate personal air samplers. Urinary mercury predictions based primarily on personal air samplers at 1 and 10 µg/m^3 are consistent with reported mean (4 µg/L) and upper-bound (20 µg/L) background levels, respectively. Thus, although mercury levels in air and urine are correlated below 50 µg/m^3, the impact of airborne mercury levels below 10 µg/m^3 is likely to be indistinguishable from background urinary mercury levels. *Key words:* air exposure, background urinary mercury levels, mercury vapor, pooled analysis, urinary mercury. *Environ Health Perspect* 111:623–630 (2003). [Online 30 October 2002] doi:10.1289/ehp.5717 available via *http://dx.doi.org/*

Public exposures to low levels of mercury have received increased attention as a result of past ubiquitous uses and releases of this metal, improved analytical detection methods, and a growing public awareness of the sources and health effects of mercury exposure (ATSDR 1999; Clarkson 2002). Much of this concern has focused on the organic form of mercury (methyl mercury) in the environment (FDA 2001; NRC 2000). However, the elemental (metallic) form of mercury can also affect the central nervous system and, like organic mercury, may be a concern for developmental effects in children (ATSDR 1999). Although dental amalgams are the primary source of elemental mercury exposure in the general population, releases of this metal from consumer products and devices (e.g., thermometers, barometers, thermostats, electrical switches, fluorescent lights, gas pressure regulators, batteries, and use of older latex paint) can also contribute to public exposures (Agocs et al. 1990; Aronow et al. 1990; ATSDR 1999, 2000; Zeitz et al. 2002).

In response to concerns about mercury vapor exposure in homes, schools, or businesses due to accidental releases from removal of gas-pressure regulators, ATSDR (2000) established a "residential occupancy level" of 1.0 µg/m^3 for elemental mercury in ambient air that was considered safe for occupants (ATSDR 2000) and protective of health, even of sensitive populations chronically exposed to mercury vapor.

Some public health agencies have also recommended biomonitoring of inhabitants in those homes where mercury has been detected above certain benchmark air concentrations (IDPH 2001; Renninger 2000). The concentration of mercury in urine is considered the most accurate biomarker for understanding the absorbed dose from chronic exposure to mercury vapor, whereas blood mercury levels are considered more appropriate for evaluating short-term or peak exposures (ATSDR 1999; Barregård 1993; Fiserova-Bergerova et al. 2000). Unlike mercury in blood, urinary mercury levels are less affected by methyl mercury exposure from the diet (ATSDR 1999). However, dietary mercury exposure from high fish consumption may contribute to urinary mercury levels (Abe et al. 1995; Suzuki et al. 1993).

The average background concentration of mercury in urine has often been reported to be about 4 µg/L in the general population, with an upper bound (e.g., 95th percentile) of about 20 µg/L (ATSDR 1999; Iyengar and Woittiez 1988; Minoia et al. 1990; Skerfving 1972; WHO 1990, 1991), although considerable variation is apparent in studies reporting background urinary mercury levels in subgroups from different locations and in those that report urinary mercury measurements for control or unexposed groups in nonoccupational or occupational settings (Table 1). More recent studies reporting levels specifically for pediatric populations have means and often upper-bound values generally well below 3 µg/L (Table 1).

Many studies have also found a strong correlation between the level of mercury in urine and the level of elemental mercury in air in occupational settings where exposures are relatively high (Ehrenberg et al. 1991; Nordhagen et al. 1994; Roels et al. 1987; Schaller and Triebig 1984; Stopford et al. 1978). Less understood is whether exposures at much lower airborne mercury levels (i.e., 1–10 µg/m^3) can be detected in urine above background levels. In fact, some reports note a lack of correlation between air and urine mercury levels at airborne concentrations < 50 µg/m^3 (ATSDR 1999; Lindstedt et al. 1979). The relationship between urine and air mercury at low levels has been difficult to assess in most studies because of inadequate data in this range of air concentrations.

We conducted a quantitative analysis of the published literature in an attempt to determine if biological monitoring of mercury in urine can be used to evaluate low-level airborne exposures to elemental mercury. In particular, we evaluated whether exposures to 1–10 µg/m^3 of elemental mercury in air will result in changes in urinary mercury levels that can be distinguished from background. Data from 10 studies were interpreted using pooled analysis techniques.

Methods

We reviewed the literature for published articles containing air and urine mercury concentration data. More than 20 articles that contained air and urine mercury data for individuals or groups were identified.

Study inclusion criteria. Many studies identified in the literature contained insufficient data or information to include in the

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